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STUDENT ID NO

## **MULTIMEDIA UNIVERSITY**

# FINAL EXAMINATION

TRIMESTER 2, 2019/2020

### **ERT3036 – ADVANCED ROBOTICS**

(RE) (OPEN BOOK EXAMINATION)

> 03 MARCH 2020 2:30 p.m. – 4:30 p.m. (2 Hours)

#### INSTRUCTIONS TO STUDENT

- 1. This Question paper consists of 5 pages including cover page with 4 Questions only.
- 2. Attempt ALL questions. The distribution of the marks for each question is given.
- 3. Please write all your answers clearly in the answer booklet provided.

- (a) A mobile robot is differentially driven with wheel radius of 0.06 m. The two wheels are separated by 0.4 m. For each complete revolution of the wheel, the quadrature encoder gives 360 pulses.  $q_1$  and  $q_2$  are the incremental encoder reading for wheel 1 (left wheel) and wheel 2 (right wheel) respectively. The coordinates of wheel 1 is resting at (0,0) at t=0 with an orientation of  $\phi=0$  radian.
  - (i) Calculate the pulses measured by  $q_1$  and  $q_2$  respectively when the robot is making 30 degrees turn in the clockwise direction with an instantaneous radius of curvature,  $R_i = 8 \text{ m}$ .

[4 marks]

(ii) Calculate the coordinates of point P which is the mid-point between the two wheels along the differential drive axis.

[6 marks]

(iii) The mobile robot will continue to rotate in the clockwise direction with an instantaneous radius of curvature,  $R_i = 10$  m. Find the ratio of the wheel velocities,  $v_2/v_1$ , where  $v_1$  and  $v_2$  are the linear wheel velocities respectively.

[3 marks]

(b) The position of a differentially driven wheeled mobile robot is represented by point P. P is located at the mid-point along the axis connecting the two motors. The width between the two motors is w = 0.5m and its length is L=1m. The mobile robot is currently located at coordinates (1.5m, 1.5m) and it is going towards its goal at point G (4m, 4m).

Circular obstacles with radius of R = 0.5m are located at point  $T_1$  (3m, 2m) and  $T_2$  (1.5m, 3m). At this point, R+s+L=2.53m and R+s+2L=3.53m. s is the minimum distance of which mobile robot must stop in front of the edge of the obstacle before colliding with it. At this instant,

$$\overrightarrow{PG} = \begin{bmatrix} 2.5 \\ 2.5 \end{bmatrix}$$
;  $\|\overrightarrow{T_1P}\| = 1.5811 \text{ m} \text{ and } \|\overrightarrow{T_2P}\| = 1.5m$ 

Find the navigation vector for the mobile robot at this point.

[12 marks]

Continued ...

2/5

A serial robot with two links is shown in Figure Q2.

Point A is located at (0,0) at the x-z plane as shown (sagittal plane). Link 1 has a length of  $l_1$  and mass of  $m_1$  while link 2 has a length of  $l_2$  and a mass of  $m_2$ . The angles of link 1 and link 2 with respect to the vertical z-axis are  $q_1$  and  $q_2$  respectively. The total kinetic energy for link 1 and link 2 is  $K_1$  and  $K_2$  respectively.

(a) Locate the coordinates for the centre of mass for link 1 and link 2.

[6 marks]

(b) Find  $K_2$  when the moment of inertial for link 2 is  $I_2$ .

[12 marks]

(c) If 
$$\begin{bmatrix} \dot{x}_{c1} \\ \dot{x}_{c2} \end{bmatrix} = J \begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \end{bmatrix}$$
, find the matrix  $J$ . [5 marks]

(d) Provide the special name for matrix J and describe its function.

[2 marks]

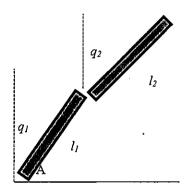


Figure Q2. Two links serial Robot

3/5

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(a) With proper diagrams, explain the mechanism of how a quadrotor fly. [2+5 Marks]

(b) Compare the good of having quadrotor in flying vehicle over fixed wing UAVs (Unmanned Aerial Vehicles).

[5 marks]

(c) A quadcopter has 4 identical motors providing a lifting force of  $F = k_F \omega^2$  each. It was known that  $k_F = 8 \times 10^{-8} \text{N/rpm}^2$ , thrust to weight ratio is 2:1, quadcopter weight is 500g, carrying 4 LiPo Battery of 50g each and a FPV camera of 150g.

(i) Calculate the total thrust of the quadcopter.

[4 marks]

(ii) Calculate the thrust per motor.

[2 marks]

(iii) Calculate the speed of each motor for hovering action.

[2 marks]

(d) A team of four (4) quadrotors are taking off from the ground and flying in a square formation for 2 meters in an indoor environment before landing again. Identify the hardware requirement and the lab setup to achieve this.

[5 marks]

Continued ...

- (a) Identify FIVE (5) human roles in human robot interaction and briefly explain EACH of them with ONE (1) task. [5 + 5 Marks]
- (b) Elaborate the term "Illustrator Cues" in human robot interaction.

[4 marks]

(c) Describe Robot's Ethics and state Zeroth Law of Robotic.

[3 + 2 marks]

(d) List down FOUR (4) Advantages of having Medical Surgical Robots.

[4 marks]

(e) Can Medical Surgical Robots fully replace human surgeon? Explain your answer.

5/5

[1+1 marks]

End of Paper ...

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